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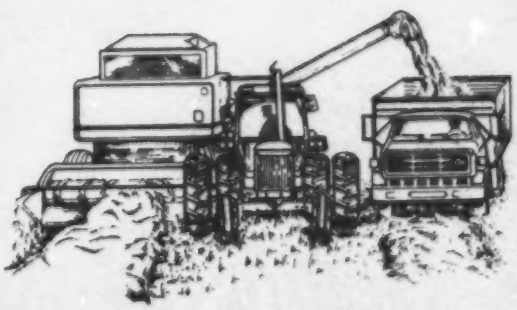
ECONOMICS OF NATURAL AIR GRAIN DRYING



ECONOMICS OF NATURAL AIR GRAIN DRYING

Foreword

This bulletin points out the economic benefits as well as the costs of natural air grain drying. A study of eleven sizes of bins compares the annual costs and investment costs of each size of bin. The cost of over drying is also calculated.

This bulletin was prepared by the Farm Management Section of Saskatchewan Agriculture. Appreciation is extended to farmers who participated in a survey and to those who reviewed this bulletin.

For further information on natural grain drying and aeration refer to the Saskatchewan Agriculture publications "Natural Air Grain Drying" and "Aeration of Grain in Storage".

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March, 1987

3M 03/87 ISBN 0-88656-462-4

Definition of Natural Air Grain Drying

The terms natural air grain drying and aeration are sometimes interchanged but there is a difference. Aeration is the movement of small volumes of air through grain at one-tenth cfm/bu.*. Aeration cools the grain, prevents moisture migration, and reduces mold growth and insect infestations. Aeration provides very little drying. Natural air drying accomplishes everything that aeration does but uses much greater air flow rates, in excess of one-half cfm/bu. The greater the air flow rate the faster the drying process, however, greater air flow rates cost more in terms of investment and operating costs.

*Cubic feet per minute per bushel.

Why Use Natural Air Grain Drying

a. Natural air drying has two advantages over hot air drying:

- Low operating cost. It generally costs one to two and one-half cents per bushel for electricity to run a natural air drying fan.

- The labour requirement of natural air drying is more flexible than for hot air drying, the bins can be sampled when time is available (i.e., damp mornings).

b. The following are advantages of drying grain regardless of the method:

- Reduced grain damage results from combining tough rather than dry grain. PAMI Report #R180, January 1981, showed the standard combine had 4.5% lower losses in tough Neepawa than dry Neepawa.

- Increased combine usage results from the addition of a drying system. Drying allows combining to start several days earlier each year. A drying system allows more hours of combining each day when damp evenings and rains result in increased kernel moisture. A drying system may take the place of a second combine.

- Reduced grade losses result from advancing the date of combining. Grade losses are caused by adverse weather conditions, and the possibility of a loss in grade becomes greater the longer the crop remains in the field.

- Retaining kernel moisture can increase grain income. Each percent of moisture removed from wheat at $3.50/bu. results in an average loss in value of 4.03/bu. If you start combining when the wheat moisture content is 14.5% then the moisture content of the last wheat to be combined may be 10.5% on a dry year. By advancing the date of harvest the amount of over dry grain is reduced. The first wheat harvested can either be dried to 14.5% or held in condition to be mixed later with over dry wheat.

c. The disadvantages of natural air grain drying are:

- Extended drying time — dependent on weather conditions.

- All grain may not be dried in the fall.

- Bins containing tough grain must be monitored until the grain is dry.

- Sampling bins is a tedious job.

- When drying a bin of grain to average dry, the grain should be moved to mix the tough and over dry grain.

Management Factors and Other Equipment Needed

- Install natural air drying equipment in large diameter bins for the lowest annual drying cost. When purchasing new bins, the large diameter, higher capacity bins will usually have the lowest annual storage cost per bushel when considering the bin and concrete floor.

- Install a fan in each drying bin. Plan to start combining early to take advantage of higher temperatures in early fall that results in lower relative humidity and in faster drying.

- Purchasing a grain moisture meter and grain sample probe will assist you in managing your natural air drying system. The moisture level of the grain going into the bin should be monitored to ensure that on average, the grain in the bin is not over dry.

Optimum Size of Existing Bins for Natural Air Drying

a) Annual costs
Assumptions are shown in Appendix A

The annual costs of natural air drying were calculated in eleven different bin sizes:

14 foot diameter - 1350, 1650 and 1950 bu.
19 foot diameter - 2750, 3300, 3850, 4400 and 5000 bu.
22 foot diameter - 4100, 5000 and 6700 bu.

Example: calculating the annual cost per bushel: 5000 bushel bin, 19 foot diameter, wheat, 1/2 cfm/bu. air flow.

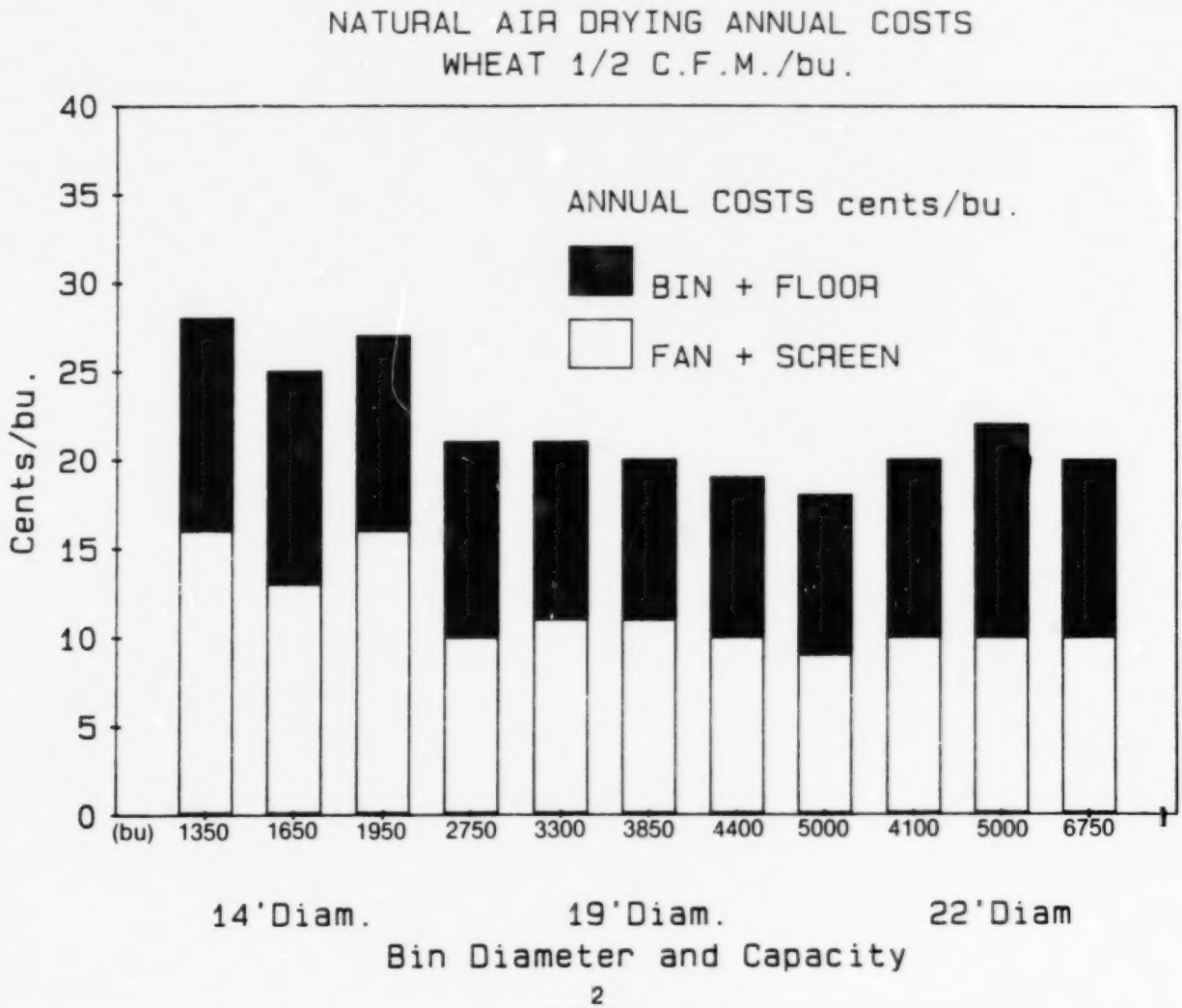
Annual Costs:

1. Fan (1452) and screen (824) = 2276		2. Bin (4219) and floor (802) = 5021	
Depreciation $\frac{2276 - 227.60}{15}$	= 136.56	Depreciation $\frac{5021 - 502.10}{30}$	= 150.63
Investment $\frac{2276 + 227.60 \times 10\%}{2}$	= 125.18	Investment $\frac{5021 + 502.10 \times 10\%}{2}$	= 276.16
Insurance 2276 x 1%	= 22.76	Insurance 5021 x 10%	= 50.21
Repairs 2276 x 3%	= 68.28	Repairs 5021 x 8%	= 40.17
			= 517.17
Power 5 hp. x 750/1000 = 3.75 kwh x .0395 x 500 hr.	= 74.06	Annual cost of bin and floor: $517.17 : 5000 bu = 10.34c//bu	
	= 426.84		

Annual cost of fan and screen:
$426.84 -: 5000 bu = 8.54c//bu

Figure 1

Natural Air Drying Annual Costs
Wheat 1/2 cfm/bu.



The same method was used to calculate the annual costs for eleven bin sizes. In Figure 1, the clear area indicates the annual cost of the fan and screen per bushel. The shaded area represents the annual cost of bin and floor. The total height shows the total annual cost. The 19 foot diameter, 5000 bushel bin has the lowest cost. Generally the cost per bushel in the 19 foot and 22 foot diameter bins are less than the 14 foot diameter bins.

b) Investment Cost

Investment cost per bushel of different bin sizes and air flows are compared in Figure 2. The total purchase price of the bin, cement floor, fan and screen was added and divided by the number of bushels.

Example: 5000 bu. bin, 19 foot diameter, wheat 1/2 cfm/bu.

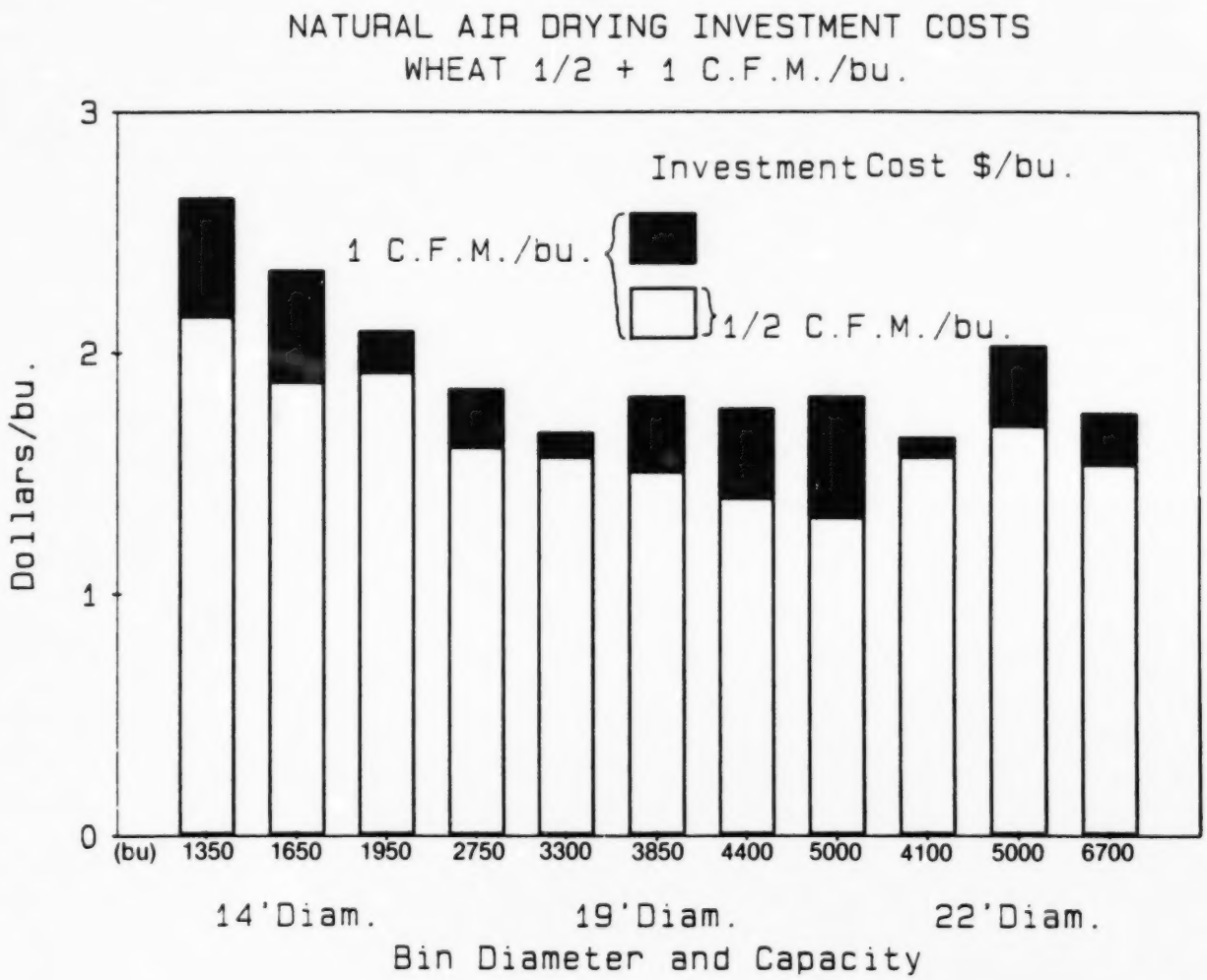
	Cost
Fan	1452
Partial flush floor screen 11' x 11'	824
Bin	4219
Cement Floor	802
Total Investment Cost	7297

Investment cost/bu. - 5000 bu. $1.46/bu.

In Figure 2, the total height of the bars indicates the investment cost per bushel of the bin, floor, fan and screen at 1 cfm/bu. air flow. The clear area of each bar represents the investment cost per bushel of the bin, floor, fan and screen at 1/2 cfm/bu. air flow.

Figure 2

Natural Air Drying Investment Costs
1/2 cfm/bu. and 1 cfm/bu.



It is not always possible to size the fan exactly for a specified air flow because of gaps in fan sizes (i.e. 1 1/2 hp-3 hp-5hp). When sizing the fan for a minimum of 1/2 cfm/bu. air flow, in some cases the air flow exceeded the 1/2 cfm/bu. rate. To size the same bin for 1 cfm/bu. air flow then requires less additional investment. In some cases sizing the fan for a minimum of 1 cfm/bu. air flow resulted in an air flow in excess of 1 cfm/bu.

MANAGEMENT OF THE NATURAL AIR DRYING SYSTEM

When filling your bins, it is important that you monitor the grain moisture level to ensure that it does not exceed the moisture level your system is designed for. Only by monitoring the moisture content of the grain can you determine when the bin is close to average dry. The grain can then be mixed in the process of moving it to another bin. The following equipment will be extremely useful in managing a drying system:

Grain Moisture Meter	800
Grain Sample Probe	58
Grain Temperature Probe	275
	$1133

COMPARE THE COST ADVANTAGES AND DISADVANTAGES OF NATURAL AIR DRYING

Consider only the fan and screen costs, assuming the bin and floor costs are allocated to the storage of grain.

Partial Budget

Combining Wheat Tough and Drying With Natural Air

Added Costs

1/2 cfm/bu., 19 ft, 4400 bushel bin with a 5 hp. axial flow fan

Depreciation		
$\frac{2276 - 227.60}{15}$	=	136.56
Investment		
$\frac{2276 + 227.60}{2} \times 10\%$	=	125.18
Insurance		
2276 x 1%	=	22.76
Repairs		
2276 x 3%	=	68.28
Power		
3.75 kwh x .0395 x 500	=	74.06
Annual cost of drying		426.84
Moving grain when average dry		
2 augers x 3.3 hr. x 9.65/hr.	=	63.69
Labour 5 hr. x 9.00/hr.	=	45.00
		108.69
Total Disadvantages		**$535.53**

Added Returns

Retaining Kernel Moisture Retain moisture at 14.5% rather than 12.5% savings of 8.03c//bu. (1) 4400 bu. x 8.03c//bu. (Table 6)	=	353.32
Reduced combine loss harvesting high moisture wheat (2) 4400 bu. x .73% x $3.50/bu.	=	112.42
Reduced cracking loss harvesting high moisture wheat (3) 4400 bu. x 1.5% x $3.50	=	231.00
Reduced grade loss (4)		
Increased combine usage (5)		
Total Advantage		**$696.74**

The net advantage is $161.21 plus any reduced grade loss by advancing the date of harvest.

(1) Retaining Kernel Moisture

Wheat at 14.5% moisture is purchased by grain companies for the same price as wheat at 10.5% moisture. 14.5% moisture wheat weighs more than 10.5% moisture wheat so it is beneficial to sell your grain at the highest allowable moisture. By combining at high moisture and drying to 14.5% moisture you can ensure that your grain is not over dry. You may want to combine some grain tough; cool it, and mix it later with over dry grain. For example, a bin of 16.5% moisture wheat could be mixed with a bin of 12.5% moisture wheat to yield an average moisture of 14.5%.
Your elevator agent may want you to haul the bins in separately so he can mix the two in the elevator to ensure proper mixing.

Drying wheat at $3.50/bu. from 14.5% to 13.5% results in the following loss in value:

At 14.5% in one bushel there is:

Water 60 lb. x .145 = 8.7 lb.
Dry Matter 60 lb. - 8.7 = 51.3 lb.

After drying to 13.5% moisture that bushel weighs:

$$\frac{\text{lb. dry matter in 14.5\% wheat}}{\text{\% dry matter in 13.5\% wheat}} = \frac{51.3 \text{ lb.}}{.865} = 59.31 \text{ lb.}$$

Loss in weight is 60 lb - 59.31 = .69 lb.

$$\text{The loss in value is } \frac{.69 \times 3.50/\text{bu.}}{60 \text{ lb.}} = 4.03\text{c//bu.}$$

The above method was used to calculate the following table:

Table 3

Change in Wheat Value by Drying
Drying One Percent

Moisture Percent	Each Percent	Cumulative Above and Below Dry	Change in Value 3300 bu. Wheat
18.5	4.24c//bu.	+16.67¢/bu.	$ +550
17.5	4.19	+12.43	+410
16.5	4.14	+ 8.24	+272
15.5	4.10	+ 4.10	+135
14.5	4.03	- 4.03	-133
13.5	4.00	- 8.03	-265
12.5	3.96	-11.99	-396
11.5	3.91	-15.90	-525
10.5			

Average 4.07c//bu.

If combining is not started until the grain is dry, several days of hot, dry weather can reduce the grain moisture content far below dry. The following example illustrates the economic loss resulting from over drying.

Example: 7 quarter farm, 1050 acres cultivated. 700 acres wheat x 26 bu./acre = 18,200 bu.

Average Grain Moisture	Loss in Value
13.5%	$ 733
12.5%	1461
11.5%	2182
10.5%	2894

(2) Reduced Combine Losses When Threshing Tough Neepawa Wheat

PAMI report #R180, January 1981 was comparing a standard combine to a Stueckle modifed combine. The results showed reduced combine losses in tough Neepawa wheat as compared to dry Neepawa wheat when the combine is in good condition and well-adjusted.
The losses from the standard combine are itemized in Figure 4.

Figure 4

Reduced Combine Losses When Threshing Tough Neepawa Wheat
(Standard Combine Losses in bu./hr.)

Type of Loss	Dry Neepawa Wheat	Tough Neepawa Wheat
Walker	1 bu/hr.	1 bu./hr.
Shoe	3	1
Unthreshed Grain	2	2
Cracked Grain	17	7
Total	23 bu./hr.	11 bu./hr.

Total Loss as a Percent of Threshed Grain:

$$\frac{23 \text{ bu./hr.} \times 100}{277 \text{ bu./hr.}} = 8.3\% \qquad \frac{11 \text{ bu./hr.} \times 100}{289 \text{ bu./hr.}} = 3.8\%$$

Shoe Loss as a Percent of Threshed Grain:

$$\frac{3 \text{ bu./hr.} \times 100}{277 \text{ bu./hr.}} = 1.08\% \qquad \frac{1 \text{ bu./hr.} \times 100}{289 \text{ bu./hr.}} = .35\%$$

Cracked Grain as a Percent of Threshed Grain:

$$\frac{17 \text{ bu./hr.} \times 100}{277 \text{ bu./hr.}} = 6.14\% \qquad \frac{7 \text{ bu./hr.} \times 100}{289 \text{ bu./hr.}} = 2.42\%$$

Combining Neepawa tough rather than dry with a standard combine resulted in a reduced loss of 8.3% - 3.8% = 4.5%

In the PAMI test, other than cracked grain, the only difference between tough and dry grain was the shoe loss. Combining Neepawa tough resulted in a reduced shoe loss of 1.08% - .35% = .73%.

(3) Reduced Cracking Loss When Harvesting High Moisture Wheat

The PAMI test (Figure 4), combining Neepawa tough rather than dry with a standard combine resulted in a reduction of cracked grain of 3.72% (6.14% - 2.42%). Although these figures are high for the average farm situation, they stress the fact that extreme cracking loss under dry conditions can be substantially reduced when grain moisture is high.

Harrison (Figure 5) calculated reduced grain damage of 1.5% (2.0% - .5%) when combining wheat at 20% rather than 12%. Harrison appears to be more in line with the actual grain damage on most farms.

Effects of Moisture Content on Threshing - HP Harrison 1975 Park Wheat

Figure 5

Moisture	Grain Damage % of Total
12%	2.0%
16%	1.0%
18%	1.5%
20%	.5%

(4) Reduced Grade Losses

Grade losses are caused by adverse weather conditions and the possibility of a loss in grade occurring becomes greater, the longer the crop remains in the field. Combining at high grain moisture and drying will advance the date of combining over combining at low grain moisture levels. Advancing the date of combining reduces the chance of grade losses.

The following table shows the value that is lost when #1 wheat drops to #2, or when #2 wheat drops to #3.

Table 6

Average Spread Between Grades of Spring Wheat
(dollars per bushel)

Grades Spread	1985-86	1984-85	1983-84	1982-83	1981-82	Average 5 Years
1CW - 2CW	$0.22	$0.26	$0.24	$0.27	$0.19	$0.24
2CW - 3CW	$0.22	$0.34	$0.32	$0.19	$0.25	$0.26

(5) Increased Combine Usage

By combining at higher moisture levels, and drying, the combine can be operated more days per year and more hours per day. The added value depends on the time of year and the anticipated weather conditions.

Conclusions

Larger diameter bins are generally the least expensive per bushel to equip with natural air drying and the least expensive when considering annual costs. Consider each bin on an individual basis and install natural air drying equipment in more bins as long as the net benefits exceed the annual drying costs. Natural air drying may enable you to sell more grain at the maximum allowable moisture thereby increasing income. Increasing total combining efficiency will also increase net profit. Whenever a grade loss can be illiminated by advancing the date of combining, the return can be substantial.

Appendix A

Assumptions

- Bin life: 30 years
- Natural air drying system life: 15 years
- Annual fan use: 1 cfm/bu. air flow - 250 hours
  1/2 cfm/bu. air flow- 500 hours
- A fan in each drying bin
- Repairs: bin - .8% of original cost per year
  Air drying equipment- 3% of original cost per year
- Electricity: 3.95/kwh (average small farm rate)
  power already in yard
- Insurance and housing: 1% of original cost
- Interest rate: 10% opportunity cost
- Cement floor: 14' diameter bin
  4.3 cu. yard x 101.95 = 438.40
  19' diameter bin
  7.87 cu. yard x 101.95 = 802.41
  22' diameter bin
  10.55 cu. yard x 101.95 = 1076.00
- Fan Prices

1.5 hp. 18'axial - 786	5 hp. cent. - 1540
3 hp. 18'axial - 1018	7 hp. cent. - 2640
3 hp. 24'axial - 1210	10 hp. cent. - 3080
5 hp. 24'axial - 1452	15 hp. cent. - 3630
	20 hp. cent. - 4070

- Flush floor screen prices:

Size
8' x 8' - 488
11' x 11' - 824
13' x 13' - 1155

Bin prices:

14' diameter	19' diameter	22' diameter
1350 bu. - 1628	2750 bu. - 2817	4100 bu. - 4056
1650 bu. - 1828	3300 bu. - 3124	5000 bu. - 5916
1950 bu. - 2053	3850 bu. - 3539	6700 bu. - 6506
	4400 bu. - 3868	
	5000 bu. - 4219	